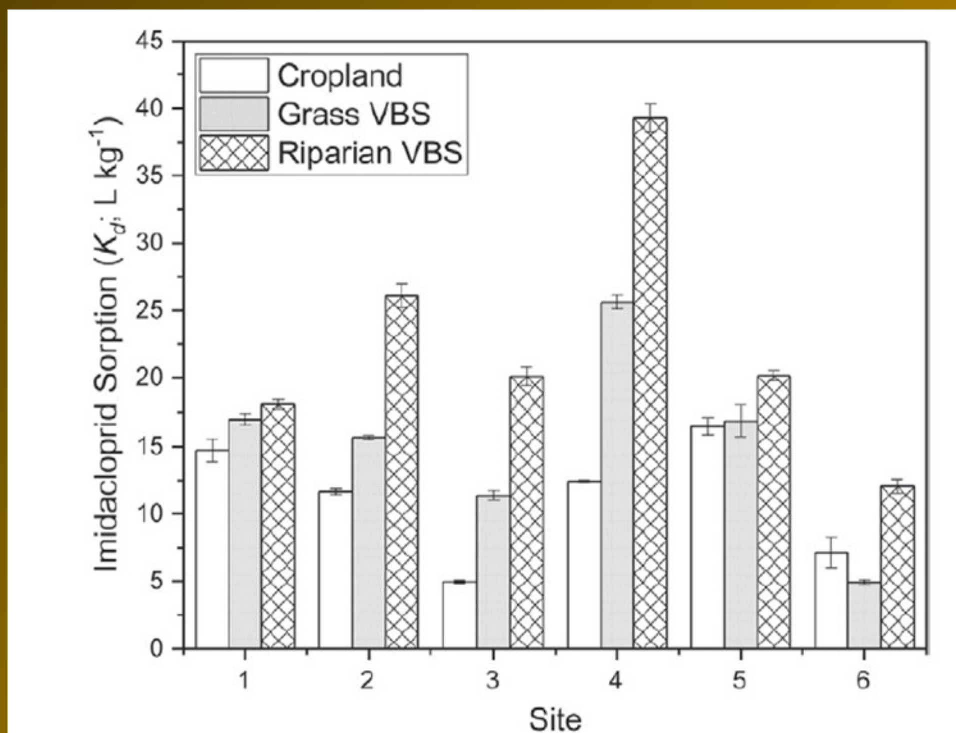
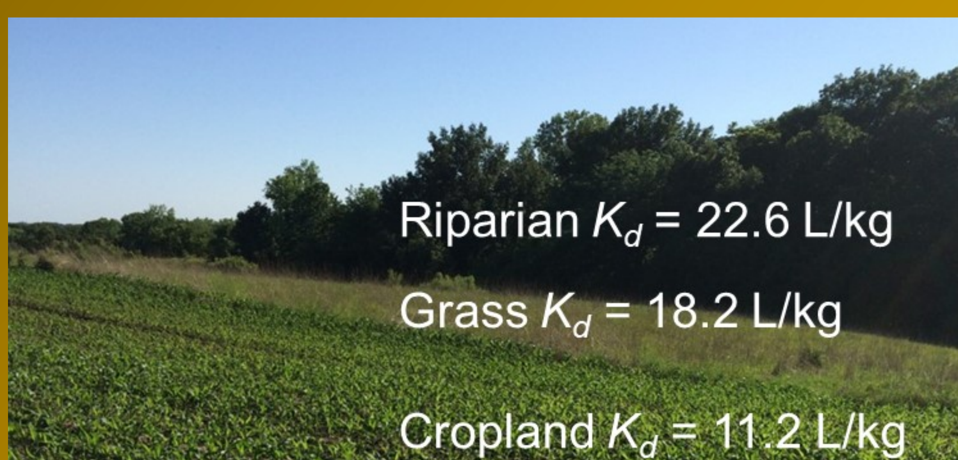
MDC Resource Science

Science Notes

Reducing Neonicotinoids in Aquatic Resources: Vegetated Buffer Strips impede imidacloprid movement in Missouri agroecosystems



Mean imidacloprid solid-to-solution partition coefficients (Kd) for cropland, grass vegetative buffer strip (VBS) and riparian VBS soils collected at six sites in northern Missouri. Error bars represent one standard deviation.



Reducing Neonicotinoids in Aquatic Resources: Vegetative Buffer Strips impede imidacloprid movement in Missouri agroecosystems

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Background:
Neonicotinoids are a class of broad-spectrum systemic insecticides frequently used in agroecosystems to control root and leaf eating pests. The widespread use and environmental persistence of neonicotinoids in the U.S. and globally has resulted in surface water contamination and build-up of neonicotinoids within other environmental sectors, such as soils and wetlands. Deleterious effects of neonicotinoids on non-target insects and wildlife heightens the need to determine practices that reduce potential for these chemicals to reach aquatic ecosystems through subsurface connections and overland surface runoff. An understanding of neonicotinoid sorption (any removal of a compound from solution to a solid phase) and transport in soil is critical for determining and mitigating environmental risks associated with this class of insecticides. We evaluated whether conservation practices, such as vegetated buffer strips (VBS), could reduce neonicotinoid entry into surface waters and aquatic ecosystems. One of the most commonly used neonicotinoids is imidacloprid (ICD) which first entered the United States markets in 1994. This Science Note focuses on differences in the sorption and transport of imidacloprid within soils collected from grass VBS, riparian VBS, and agricultural fields planted to corn/soybean.

Method:
Soils were collected at six randomly chosen Conservation Area (CA) sites within grids that encompassed all three land uses (grass VBS, riparian VBS, and cropland). Single-point, batch sorption experiments were conducted using radio-labeled (^{14}C) ICD to determine the extent ICD sorbed to the different soil types (i.e., K_d coefficients). Column experiments were conducted to determine transport rates using soils collected from the three vegetation treatments at Thomas Hill Reservoir CA. Soil was packed into glass columns and water flow was characterized by applying Bromide (Br) as a nonreactive tracer to verify the column was packed without physical abnormities. A single pulse of aqueous ^{14}C-ICD was then applied, followed by up to 45 days of calcium chloride ($CaCl_2$) solution, and ICD leaching was monitored. Bromide and ICD breakthrough curves for each column were simulated using CXTFIT and HYDRUS-1D models.

Results:
Sorption results indicated that ICD sorbed more strongly to soil from riparian VBS (K_d = 22.6 L kg^{-1}) than crop fields (K_d = 11.3 L kg^{-1}; $p = 0.04$), and soil organic carbon was the strongest predictor of increasing ICD sorption ($p < 0.0001$). The column transport study found delayed ICD peak concentrations and greater retention of the ICD applied in the grass and riparian VBS soil compared to the crop field soil (Figure 1). HYDRUS-1D results indicated that the two-site, one-rate linear reversible model best-described results of the breakthrough curves, indicating the complexity of ICD sorption and demonstrating its mobility in soil. Greater sorption and longer retention by grass and riparian VBS soil compared to crop soil suggests that VBS may be a viable means to mitigate ICD loss from agroecosystems and deter ICD entry into aquatic ecosystems.

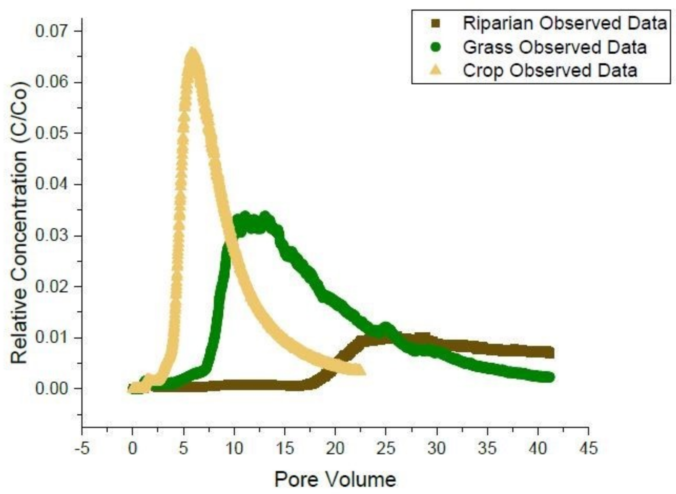

Figure 1. Imidacloprid breakthrough curves for soil columns packed to cropland, a grass vegetative buffer strip (VBS) and a riparian VBS collected from Thomas Hill Reservoir CA. Delayed peak pore volumes and increased retention of ICD in the grass and riparian VBS indicate greater sorption and slower ICD transport.

Management Implications:
ICD is highly mobile in soil but sorbs more strongly in sites with greater soil organic carbon. Transport of ICD from crop fields can be reduced by implementing agriculture practices that increase soil carbon content, such as: no-till planting; establishment of grass VBS at field edges; and use of cover crops (e.g., winter cover crops, crop rotations using cover crops). Additionally, maintaining or expanding riparian corridors adjacent to or near Missouri surface waters and wetlands could reduce neonicotinoid infiltration into aquatic ecosystems. The bioavailability of ICD to VBS plants and other non-target organisms is currently unknown.

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